Agricultural Innovations for Climate Change Adaptation and Food Security in Africa: The Cases of Ghana and The Gambia

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Gordon Akon-Yamga
Paul Boadu
Beatrice Darko Obiri
Joyce Amoako
Fatou Janha Mboob

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Gordon Akon-Yamga
Science and Technology Policy Reseach Institute (CSIR-STEPRI), Ghana

Paul Boadu
Science and Technology Policy Reseach Institute (CSIR-STEPRI), Ghana

Beatrice Darko Obiri
Forestry research Institute of Ghana (CSIR-FORIG), Ghana

Joyce Amoako
Water Research Insitute (CSIR-WRI), Ghana

Fatou Janha Mboob
Try Women's Group, The Gambia

AFRICAN TECHNOLOGY POLICY STUDIES NETWORK

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Table of Contents

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1. Introduction

Studies have shown that Ghana's climatic conditions have changed in the past four decades (Agyeman-Bonsu et. al, 2008). Analysis by Agyeman-Bonsu et. al. (2008) showed that both maximum and minimum air temperatures increased by 2.5 and 2.2°C respectively between 1961 and 2001. Reports by the Intergovernmental Panel on Climate Change (IPCC) suggest that agricultural yields will suffer negative consequences if no serious intervention is carried out (IPCC, 2007). Therefore the impacts of climate change and variability will outweigh economic and population growth factors, yet these factors may intensify the impacts.

In The Gambia, the Government (2003) used forty years (1951-1990) of current climate data to develop the baseline climate scenarios with the analysis showing that in the 1951-1990 period, the behaviour of the climate of the country showed almost equal distribution of wet/cool and dry/warm years. Thus, the 1951-1980 period was wetter and relatively warmer while the 1961-1990 period was drier and cooler. However between the two periods, the rainfall for the months of July and September significantly decreased.

Furthermore, it is projected that by 2075, average mean temperature of The Gambia will increase by a margin of between 3°C to 4.5°C depending the model used, and by 2100 a decrease of 59% (HCGG), 17% (HCGS) and 15% (GFDL equilibrium model), and an increase of about 15% (GFDL01) and 29% (CCCM) about the 1951-1990 average rainfall amount are projected in The Gambia (The Government of Gambia, 2003). On the impact of such change on food availability, The Government of Gambia (2003) predicts that all crop growth parameters (kg dm/ha) for the maize crop would undergo significant reductions under climate change. Furthermore, grain weight is estimated reduce lower than current climate values; leaf and stem weights are also expected to be lower than current climate values by amounts ranging from 18 – 35% and 17 – 34%, respectively; and the nutritional value of the biomass products from maize will also be decreased due to decrease in nitrogen content, a situation that is similar for millet.

The impact of such changes and outcomes on society has often been seen as normal and part of life. This is because livelihood options have turned into adaptation strategies, where there is no clear transition, adaptation to extreme events are considered as part of livelihoods. The riots and protest due to food shortage and prices in 2007-2008 point to some of the signs of increasing food insecurity in many countries in sub-Sahara Africa, yet there exist innovations that can be used to stem the tide of food insecurity.

A recent study conducted by CSIR-STEPRI of Ghana (Obirih-Opareh et al., 2008) shows that there exists numerous agricultural innovations that have not been used and yet they hold potential for improving food production in Ghana and Africa. However it is not known which of these innovations are most suitable for climate change adaptation. It is in this light that this research is founded; to document indigenous and emerging innovations and good practices for climate change adaptation and food security in Ghana and the Gambia.

1.1 Objectives

The main goal of the study was to support the ATPS Programme on Agricultural Innovations for Climate Change Adaptation and Food Security in Africa by achieving the following specific objectives:

Identify and document indigenous innovations and good practices by climate change vulnerable communities for improved food security in Ghana and The Gambia;

Provide information on agricultural practices and activities of farmers towards food security and climate change adaptation in Ghana and Gambia;

Identify and document emerging innovations suitable for climate change adaptation in Ghana and The Gambia;

Promote selected agricultural innovations through targeted training and field demonstrations with selected agriculture extension officers and farmers in Ghana and The Gambia;

Establish collaborative network involving researchers, ministry of food and agriculture or its equivalent and farmers to enhance agricultural innovations for increased productivity in the face of climate change; and

Provide baseline information to support agricultural innovation programmes and the implementation of the NEPAD CAADEP programme in the West Africa region through popularization and policy advocacy.

2. Literature Review

2.1. Innovation System

The concept of innovation system provides many opportunities for learning about how a country's agricultural sector can make optimum use of new knowledge and to design new interventions that go beyond research and investments (World Bank, 2007). Therefore agricultural innovation system can be seen as the best approach to ensure food security in Africa. Innovation system thinking represents a significant change from the conventional linear approach to research and development. It provides analytical framework that explore complex relationships among heterogeneous agents, social and economic institutions, and endogenously determined technological and institutional opportunities. It demonstrates the importance of studying innovation as a process in which knowledge is accumulated and applied by heterogeneous agents, through complex interactions that are conditioned by social and economic institutions (Agwu et. al., 2008).

Innovation is an interactive process involving various critical actors working in a given socio-economic and cultural system to bring about improvements or advances in the production of goods and services. It is a dynamic process and it implies specific behaviours and performances, with obvious implications for outcomes. The concept of Innovation System has become an important framework for understanding technology development and diffusion in recent times (Nelson, 1993; Mytelka, 2000; World Bank, 2007). The framework stresses that innovation is neither research nor science and technology, but rather the application of knowledge (of all types) in production to achieve desired social or economic outcomes. This knowledge might be acquired through learning, research or experience, but until applied it cannot be considered innovation.

While this knowledge can be brand new innovation often involves the reworking of the existing stock of knowledge, making new combinations or new uses (Edquist, 1997).

The origin of this framework is the concept of a national system of innovation (Freeman1988, and Lundval 1991). It emerged as a response to the limited explanatory power of conventional economic models that view innovation as a linear process driven by the supply of research and development (R&D). Instead the innovation systems framework conceptualised innovation in more systemic, interactive and evolutionary terms whereby networks of organisations, together with the institutions and policies that affect their innovative behaviour and performance, bring new products, new processes and new forms of organization into economic use (Nelson and Winter 1982, Freeman 1988, Lundval 1992; Edquist 1997).

Different approaches to promoting agricultural innovation have emerged since the 1980s. The period before the mid-1980s emphasised the creation of National Agricultural Research Systems to strengthen research at the national level and to encourage technology transfer and invention. In the 1990s, this approach changed to the pluralistic agricultural knowledge and information systems which emphasised greater client participation and financing, technology adoption and adaptation, and knowledge exchange mechanisms. More recently, the agricultural innovation system approach incorporates major agents such as universities, firms and other organisations that can tap into the growing stock of global knowledge to local needs, and create new technology and products. Within the changing agricultural context, agricultural innovation system emphasises technology and knowledge generation and adoption rather than strengthening research systems and their outputs (Kim et. al., 2007).

The innovation concept has been used by Sahel and West Africa Club (SWAC, 2005) in a broad sense, integrating institutional, policy and organisational innovations. It includes:

i. Physical innovation (example: crop varieties, animal breeds, etc.);
ii. Institutional, social, organisational innovations (example: setting up producers' networks, better organisation of input distribution networks, etc.);
iii. Innovations in terms of information and practices (example: cultural practices).

For each type of innovation, endogenous innovations (farmer innovations) can be distinguished from exogenous innovations (innovations derived from research, extension, private companies, and agribusiness, etc.).

2.2. Climate Change

The climate is a system involving highly complex interactions between the atmosphere, the oceans, the water cycle, ice, snow and frozen ground, the land surface and living organisms. This system changes over time in response to internal dynamics and variations in external influences such as volcanic eruptions and solar radiation.

The atmospheric component is the most unstable and rapidly changing part of the climate system. The atmosphere is divided into five layers with different temperature characteristics. The lower two—the troposphere and the stratosphere—have the most influence on the climate system. The troposphere extends from the surface of the earth to an altitude of between 10 and 16 km. Clouds and weather phenomena occur in the troposphere, and greenhouse gases absorb heat radiated from the earth. The stratosphere, which extends from the boundary of the troposphere to an altitude of around 50 km, is the second layer of the atmosphere. The stratosphere holds a natural layer of high ozone concentrations, which absorb ultraviolet radiation from the sun. The balance of energy between the layers of the atmosphere is a major driver of atmospheric and ocean circulation, which leads to weather and climate patterns (IPCC 2007).

The Earth's climate has always changed and evolved. Some of these changes have been due to natural causes but others can be attributed to human activities such as deforestation and to atmospheric emissions, from, for example, industry and transport, which have led to gases and aerosols being stored in the atmosphere. These gases are known as greenhouse gases (GHGs) because they trap heat and raise air temperatures near the ground, acting like a greenhouse on the surface of the planet.

The Intergovernmental Panel on Climate Change (IPCC, 2007) defines climate change as "a change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean and/or variability of its properties, and that persists for an extended period, typically decades or longer". Climate change may be due to natural internal processes or external influences, or to persistent anthropogenic changes in the composition of the atmosphere or land use. On the other hand, the United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as “change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods” (UN 1992).

It is important to distinguish between climate change and climate variability. According to the World Meteorological organisation (WMO, 2010) climate variability refers to “variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forces(external variability)”. The UNFCCC makes a distinction between "climate change” which is attributable to human activities altering the atmospheric composition, and "climate variability" attributable to natural internal climate system process. However, in the context of this study there is no distinction between the two. Making a distinction between climate change and variability will entail careful comparison between observed changes and those that are expected to result from external forcing. These expectations are based on physical understanding of the climate system, which is based on physical principles. This understanding can take the form of conceptual models or it might be quantified with climate models (IPCCC, 2007), but the respondents we envisaged to talk to mostly do not have such understanding and therefore it would be difficult to them to make such a distinction.

The warming of the climate system evident in the last half century is a result of the cumulative effect of all the natural and human drivers that influence the amount of warming or cooling in the system. The dominant influence since 1750 has been an increase in concentrations of carbon dioxide. Aerosols have had a net cooling influence, although this effect is poorly understood. Natural variability in solar radiation has had a small warming influence, but there is a high level of uncertainty in the magnitude of the effect (IPCC 2007).

According to the IPCC (2007), Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases. It accordingly states that a global assessment of data since 1970 has shown it is likely that anthropogenic warming has had a discernible influence on many physical and biological systems.

There are many forecasts and indeed recorded cases of dire consequences or impacts of climate change. These, amongst many include:

- A general reduction in potential crop yields in most tropical and sub-tropical regions – for most projected increases in temperature;
- A general reduction in potential crop yields in most regions in mid-latitudes, with some variations, for increases in annual average temperatures of more than a few degrees Celsius;
- Less water in many water-scarce regions, particularly in the sub-tropics;
- Greater exposure to heat stress, vector-borne diseases such as malaria and water-borne diseases such as cholera;
- Increased risk of flooding of human settlements because of heavy precipitation and sea-level rises – tens of millions of people will be affected;
- Increased demand for energy for space cooling because of higher summer temperatures.
- Increased demand for energy for space heating during sever winters.

2.3. Adaptation to Climate Change

Two main responses have been identified by which societies can respond to climate change. These are adapting to its impacts and reducing the green house gas (GHG) emissions (mitigation), thus reducing the rate and magnitude of change. However, there is tension between these two-adaptation and mitigation (Henson, 2008). While mitigation seeks to limit climate change by reducing the emissions of GHG and by enhancing 'sink' opportunities, adaptation aims to alleviate the adverse impacts through a wide-range of system-specific actions (Fussel and Klein, 2002).

The IPCC defines adaptation as "adjustments in ecological, social or economic systems in response to actual or expected stimuli and their effects or impacts. This term refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change" (IPCC 2001).

Albeit both mitigation and adaptation measures must be pursued to tackle the climate change problem and to create an effective and inclusive international climate change regime, more attention has been devoted to mitigation in the past, both in scientific research and policy debate. Sensitivity to the issue of adaptation has grown over the last couple of years, particularly after the IPCC Third Assessment Report (TAR). Adaptation has now emerged as an urgent policy priority, prompting action both within and outside the climate change negotiations (Parry et al. 2005). According to Cohen et. al. (1998), one plausible reason for the focus on adaptation could be that climate change emerged as a problem related to the long-term disturbance of the global geo-biochemical cycles and associated effects on the climate system.

The United Nations Framework Convention on Climate Change (UNFCCC) provides that all Parties must formulate and implement national or regional programmes containing measures to facilitate adequate adaptation to climate change (Art. 4.1. b). It lists specific domains in particular need of adaptation, namely coastal zones, water resources, agriculture, and areas affected by drought and desertification, as well as floods.

2.4. Food security

Food security has been defined by Cook and Frank (2008) as "Access by all people at all times to enough food for an active, healthy life. Food security includes at a minimum:

(i) The ready availability of nutritionally adequate and safe foods, and
(ii) An assured ability to acquire acceptable foods in socially acceptable ways (e.g., without resorting to emergency food supplies, scavenging, stealing, or other coping strategies)".

The World Food Summit Plan of Action defines food security in the following terms: "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996). Food security comprises four dimensions:

(i) Adequacy of food availability;
(ii) Stability of supply;
(iii) Physical and economic accessibility of food; and
(iv) Quality and safety of food.

The standard definition of food security according to the World Bank (1986) is “access by all peoples at all times to enough food for an active, healthy life”. Statistics of food security are usually computed for individual nation states. These may be aggregated for the world's major regions to demonstrate interregional disparities at global scales. National food security is a derivative of a balance sheet in which the population nutritional requirements are balanced by supply either from production or through international trade. Computed in per capita terms, national food security, usually assumes equitable sharing of available food stock between regions, between social classes, and between members of the same household.

A food secured world cannot be adequately represented at either the regional or the national level. The security envisaged should be at all levels of human organization, including the individual, the household and the community. At the individual household level, appropriate and sufficient food could be secured with income available for food purchases, from farmland harvests, or from a combination of these and other sources. Therefore basically, food security is a function of agricultural production, which may be constrained by physical, biological and economic factors. However, a total failure of agricultural production to provide the required food will not automatically result in food insecurity provided the household can earn enough from employment and other engagements to purchase from the market.

FAO's methodology for evaluating the number of undernourished persons, which takes into account the amount of food available per person in a given country and the extent of inequality of access to food. This approach is reinforced by the emerging consensus that food insecurity in SSA is a product of both limited food availability and restricted access to food (FAO, 2006). Therefore, in this study food security was analysed mostly from the point of view of availability and accessibility.

3. Methodology

The study was carried out in Ghana and The Gambia. Ghana lies on the south-central coast of West Africa between latitudes 4°5'N and 11°5'N and longitude 3°5'W and 1°3'E. The Gambia is the smallest of the two countries (approximately11,000 km^2), lying between latitude 13° and 14° North, and 17° and 12° West. It consists of a narrow strip of land some 400 km long and 30 km wide on both sides of The Gambia River.

Two methods were employed for this study. These were field survey and desk research. These methods yielded both primary and secondary data. To allocate the number of household heads for the field survey between Ghana and the Gambia the ratio of the populations of the two countries was used. Therefore relying on the ratio of the population of Ghana (23,350,927) to the Gambia (1,660,200) as the basis for allocating the number of households to be selected from each country, 747 households were allocated to Ghana and 53 households were allocated to the Gambia to complete the proposed overall sample size of 800. However it was realized 53 households was too low a sample and therefore during the survey 100 households were selected from the Gambia and 746 from Ghana.

In order to increase precision and reliability of the data and results of the survey, stratification was employed to select the hoseholds. This was done by taking into consideration the geographical distribution, ecological zones and population distribution as the main control. In both countries, districts were grouped according to their administrative regions. In Ghana, one district was selected within each region using the simple random sampling technique. In the Gambia, however, two regions were randomly selected initially and within these two regions, one district each was selected using the simple random sampling. Within the selected districts a list of five major food producing communities was obtained from the state ministry or department responsible for agriculture. From this list some communities were randomly selected. The number of communities selected per ecological zone or district depended on the total population per community and the total sample per ecological zone. Within each of the identified communities, the survey team entered and met with the leader/head of the community to introduce themselves, explain their mission to the leadership of the community, seek the permission of the community to carry out the survey, and to request for the assistance of someone who knows the community very well.

At the community level, an enlistment of the households was conducted with the assistance of a member of the community who knows it very well. This provided the sampling frame of households at the community level from which the households interviewed were randomly selected. Once a household has been selected, the whereabouts of the head was sought after exchanges of pleasantries. In the absence of the head, the next most responsible person in the household who must also be a farmer was selected and the questionnaire administered to him or her. The questionnaire covered the demographic characteristics of the respondent, agricultural activities of the household, farmers' level of awareness of climate change, the household's access to food, the adaptation measures taken by farmers, the innovations of farmers and the extent to which they network with others.

The data collected was entered, cleaned and analysed using STATA.

4. Fieldwork Data & Preliminary Analysis

4.1 Farm Characteristics

Majority of the farmers interviewed in Ghana were mainly engaged in crop cultivation. Indeed 99.9% of the respondents were into crops cultivation as their main farming activity, whiles 0.1% was engaged mainly in livestock rearing. It should however be added that many of those engaged in crop production as their main farming activity were also engaged in raising livestock on the side. Table 1 shows that most of the farms (74.1%) were small farms; being less than five hectares under cultivation. On the other hand about a quarter of the farmers cultivated medium sized farms of between five and twenty hectares, and only 0.7% of the respondents cultivated farms categorized as large, that is of size more than 20 hectares. There were no large scale farmers among the respondents from the Gambia. About 49% of the respondents had small-scaled farm lands (less than 5ha) whereas 51% had medium-scaled farm lands (5-20ha). See Table 1. In terms of ownership of the farms, many of the respondents (99.1%) worked on their own farms although this number includes farms that belong to families. About 0.7% of the respondents in Ghana said the ownership of their farms was joint ownership whiles 0.3% of the respondents said their farms had foreign ownership.

The main areas of farming focus of respondents in the Gambia were crops and livestock. About 54% of the respondents were engaged in the cultivation of various crops whereas 46% of them were in livestock. Farm lands used for agricultural purposes by respondents in the Gambia were all privately/familyowned.

Table 1: Farm size

Responses	Ghana Percentage (n=746) .	The Gambia Percentage (n=100)
Small-size < 5ha	74.1	49.0
Medium-sized 5-20ha	25.2	51.0
Large-size >20ha	0.7	0
Total	**100**	**100**

4.2. Farmers' Level of Awareness of Climate Change

The survey sought to determine the level of knowledge of the climate change phenomenon among famers and the experiences of farmers with respect to the manifestation of climate change.

4.2.1. Farmers' Perception of Climate Change

The results from Ghana show that many of the farmers interviewed (60%) knew and were able to describe climate change. However 40% of the respondents did not know anything about climate change. The level of awareness among farmers in the Gambia of climate change issues was very encouraging. About 91% of the farmers interviewed revealed that they were aware of climate change whilst only 9% of them reported they know nothing about the issue. Farmers were further asked whether in their view the current state of the climate would change for a 'better' one that they knew some years back. To this, 74% of the respondents in Ghana said yes, 11.4% said no and 14.6% said they do not know. For the Gambia, a greater number (74%) of farmers believed there was the possibility for the climate change to reverse in the near future. On the other hand, 25% of them were uncertain about changes in the situation any time soon.

Additionally farmers were asked about their experiences with the onset of the last rainy season preceding the survey. About 57% of the respondents indicated that it did not rain at the right time at the last planting season to enable them farm. On the other hand, about 43% responded that the rains came at the right time in the last planting season. Table 2 shows the disaggregation of the responses according to the ecological zones in Ghana. It shows that farmers in the Deciduous Forest and Transition Ecological Zones mostly reported that the rains did not fall at the right time for them to start planting with 65% each answering "no". These ecological zones were followed by Sudan Savannah with 60.6%, Coastal Savannah with 52.4%, Rain Forest with 40.8% and the Guinea Savannah Zone with 34.6% responding that the rains did not fall at the right time of the planting season preceding the period of the survey (see Table 2a). Majority (74%) of the farmers in the Gambia revealed that the rains occurred at the right time in the last planting season before the survey year. On the other hand, 26% of them however reported otherwise (Table 2b).

Table 2a: Onset of rains in the last planting season in Ghana by ecological zone.

Ecological zone	Yes	No	Total
Coastal Savannah	48	52.0	100
Deciduous forest	34.15	65.9	100
Guinea Savannah	65.38	34.6	100
Rain Forest	59.21	40.8	100
Sudan Savannah	39.44	60.6	100
Transition Zone	35	65.0	100
All	**43.16**	**56.84**	**100**

Table 2b: Onset of rains in the last planting season in The Gambia.

Response	Freq	Per
Yes	74	74
No	26	26
Total	**100**	**100**

In addition to the farmers' perception about climate change, especially using rainfall and temperature as proxy indicators, farmers were asked if they have noticed other changes in their environment. The results indicate that losses of vegetation cover and wildlife dominated the responses from both Ghana and the Gambia. In Ghana 78.7% mentioned loss of vegetation cover and wildlife whiles 4.8% responded that they have observed an increase in vegetation cover and wildlife. Farmers also responded that they have noticed an increase in the number of pests and diseases (1.7%), whiles some responded that they have noticed a decrease in the number of extreme weather events (1.2%). See Table 3a.

In the Gambia, some noticeable environmental changes that farmers have observed over the past years have been decrease in vegetation cover and wildlife and also decrease in the frequency of extreme weather conditions. On the contrary some farmers (14.4%) held it that there has been an increase in vegetation cover and wildlife numbers. Farmers who hold that vegetation cover and wildlife amount has been decreasing were 84.4% of the total number of respondents (Table 3b).

Table 3a: Other perceived environmental changes in Ghana

Responses	Frequency	Percentage
Vegetation cover and wildlife amount is decreasing	587	78.7
Vegetation cover and wildlife amount is increasing	36	4.8
Decrease in frequency of extreme weather events	9	1.2
Increase in the number of some pest/diseases	13	1.7
Other	101	13.5
Total	**746**	**100**

Table 3b: Other perceived environmental changes in the Gambia

Observations	Frequency	Percentage
Vegetation cover and wildlife amount is decreasing	76	84.4
Vegetation cover and wildlife amount is increasing	13	14.4
Decrease in frequency of extreme weather events	1	1.1
Total	**90**	**100**

4.2.2 Perceived Impact of Climate Change

Figure 1 shows that farmers in Ghana perceived the loss of forest resources as the major impact of climate change in their localities. The figure indicates that the trend of forest loss has consistently increased between 2005 and 2009. Furthermore, the figure shows that flooding, long period of the dry season, soil infertility, drying of rivers, long period of rains, decrease in farm yields and delays in the onset of rainfall during the rainy season. The Figure clearly shows that the responses of the farmers indicate that the trend of these impacts has being for the worse from 2005 to 2009.

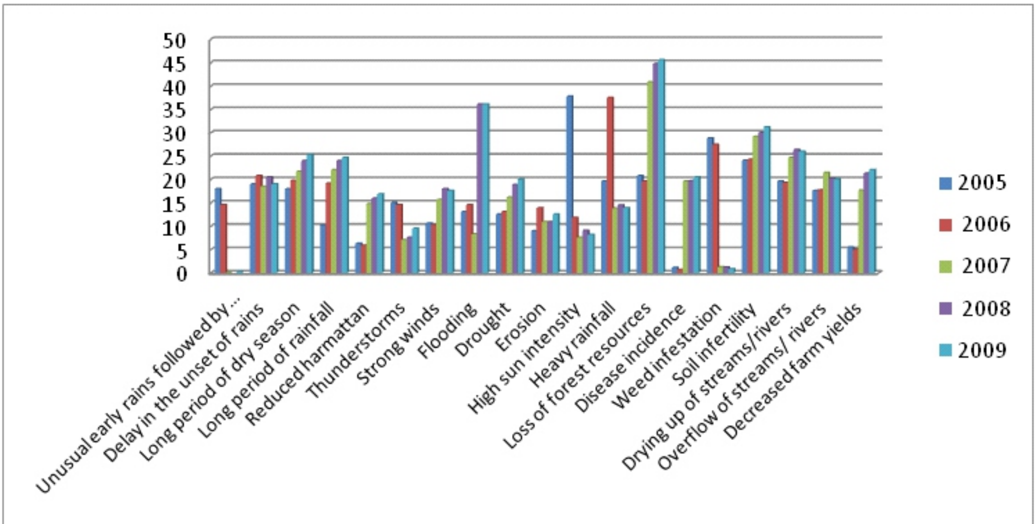

Figure 1: Farmers' perception of impact of climate change

4.2.3 Famers' Household Access to Food

As an indicator of household food security in the study areas in Ghana, famers were asked about the frequency with which they had problems meeting their household feeding. Figure 2 shows that majority of the respondents (45.3%) said they sometimes experienced problems with feeding in their households. Furthermore, 6.3% said they often faced problem with household feeding, 5.4% said they always faced problems, whiles 14.6% said they seldom encountered problems. Therefore overall, this means that 72.6% of the respondents have in some form experienced problems with meeting household feeding.

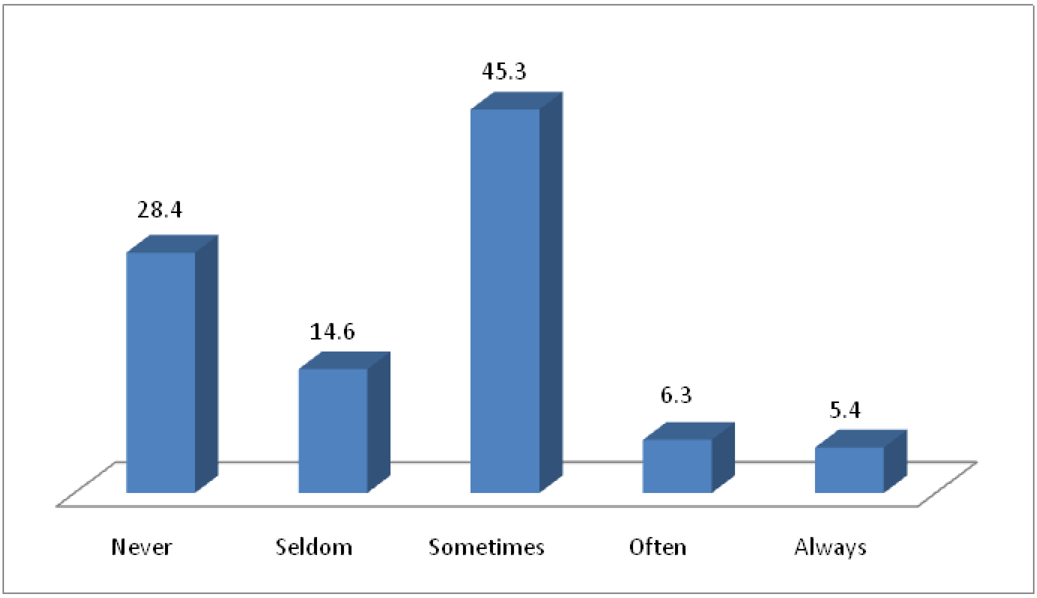

Figure 2: Frequency of household feeding in Ghana within the year preceding the survey

In the Gambia, Table 4 shows that majority of the farmers (75%) sometimes find it difficult meeting the food needs of their family. Very few of the farmers (11%) never faced any challenge in meeting the food needs of their households. Respondents who seldom faced problems of meeting their household food needs accounted for 10%. However those who regularly faced the problem of meeting their food needs accounted for only 1% (Table 4).

Table 4: Frequency of household feeding in the Gambia within the year preceding the survey

Response	Frequency	Percentage
Never	11	11
Seldom	10	10
Sometimes	75	75
Often	1	1
Always	1	1
No response	2	2
Total	**100**	**100**

Table 5: Frequency of household feeding by ecological zones in Ghana within the year preceding the survey

Ecological Zone	Never	Seldom	Sometimes	Often	Always	Total
Coastal						
Savannah	16.0	13.5	59.5	6.0	5.0	100
Deciduous forest	33.5	16.7	36.9	5.2	7.7	100
Guinea						
Savannah	32.7	11.5	38.5	11.5	5.8	100
Rain Forest	22.4	6.6	59.2	6.6	5.3	100
Sudan Savannah	32.4	12.7	40.9	12.7	1.4	100
Transition Zone	45.0	23.3	31.7	0.0	0.0	100
Total	**28.4**	**14.6**	**45.3**	**6.3**	**5.4**	**100**

When considered along the ecological zones in Ghana, the indication is that the problem of meeting household feeding is more pronounced in the Coastal Savannah Ecological Zone where only 16% of the respondents said they have never experienced problems with meeting their household food needs, followed by the Rain Forest Zone with 22.4%; the Sudan Savannah Zone with 32.4%; the Guinea Savannah Zone 32.7%; Deciduous Forest Zone with 33.5%; and the Transition Zone with 45% of the respondents saying they have never experienced problems meeting their household feeding requirements (see Table 5). In terms of the severity of the problem with meeting household feeding requirements, respondents in the Deciduous Forest Zone recorded the highest responses for those who always faced problems with meeting household feeding, followed by the Guinea Savannah, Forest and the Sudan Savannah Ecological Zones (see Table 5).

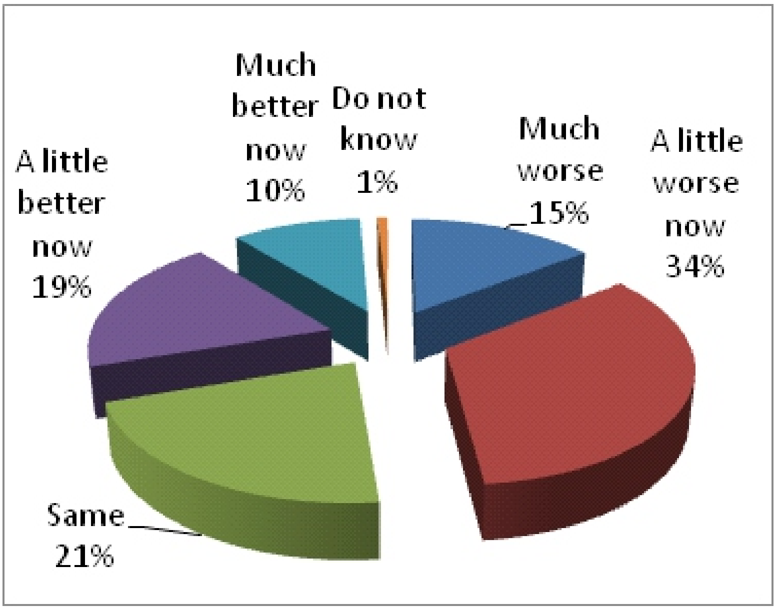

Figure 3:Farmers' comparison of current food situation of household to previous year in Ghana

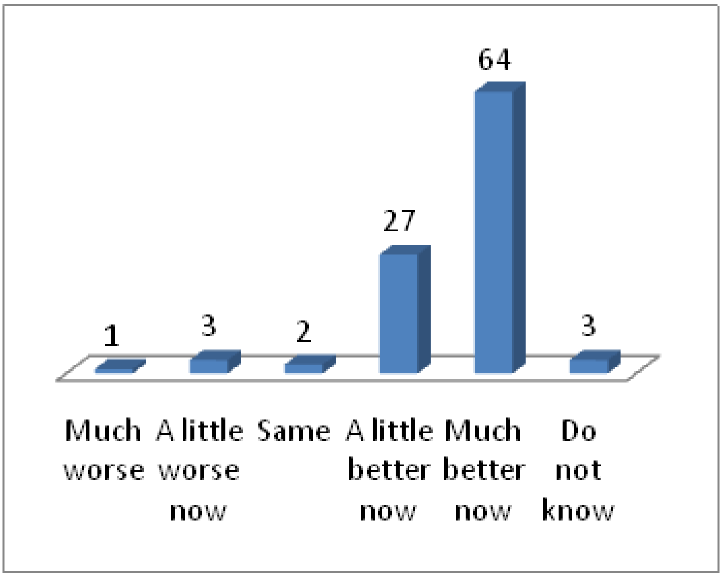

Figure 4: Farmers' comparison of current food situation of household to previous year in Gambia

Notwithstanding the status of food availability in the household of the respondents, a relative majority (43%) of the famers indicated that the household food situation at the time of the survey was a little worse than the previous year; 21% responded that the situation has not changed for them; 19% said the situation has improved a little for them; 15% said the situation is much worse; 10% said the situation is much better; and 1% said they cannot tell whether their household food situation has changed between the two periods (see Figure 3).

Gambian farmers' food situation in the year the survey was conducted was generally much better than the year before the survey. This is asserted by the number of farmers (64%) who responded positively to the fact that their food situation in the year of the survey was much better than that of the previous year. About 27% of the farmers agreed that their food situation currently is a little better than the previous year. Therefore, 91% of the respondents in the Gambia say their food situation currently has improved over the previous year. On the other hand, only 4% of the respondents gave indication that their food needs have become worse (Figure 4)

4.3 Famers Adaptive Responses to Climate Change

4.3.1 Farmers' Adaptive Responses to Erratic Rainfall Pattern

Farmers' adaptive responses to erratic rainfall patterns were examined. Table 6a, it is illustrates that the relative majority of the framers interviewed during the survey in Ghana (29.8%) said they did nothing in seasons where they had little rainfall. Other farmers said they regularly weeded their farms (22.7%); applied fertilizer (10.2%); irrigated their farms (8.7%); early cultivation; spraying with agro-chemicals (2.1%); and the application of manure (1.8%). It is interesting to note that the use of irrigation as an adaptive response to low rainfall has not caught on with farmer respondents in Ghana.

The situation was no different in the Gambia as majority of the respondents there (33%) also did nothing. About 17% of them said they provide water to their livestock whereas 7% consult with the agricultural extension agents and 4% pray to God for relief (Table 6b).

When it comes to farmers' response to excessive rainfall, the results show the same trend in both countries. In Ghana most the respondents (49.9%) said they did nothing when their farms and livestock come under excessive rainfall; followed by 18.1 who said they usually construct trenches and drains on their farms for the excess water to flow away. Other responses of Ghanaian respondents included frequent weeding of the farms (4.7%), early harvesting (1.6%) and replanting of drowned crops (1.3%). On the other, 21.3% of the respondents said they do not experience heavy rains (Table 7a).

For the Gambia, most of the respondents did not answer this question, whiles 32% of them said they report to the Veterinary Officers; an indication that during such occasions the livestock frequently get sick. Additionally, 23% said they usually do nothing about the excess rainfall (Table 7b).

Table 6a: Farmers' adaptive responses to low/ little rainfall in Ghana

Response	Freq.	Per.
No response	99	13.3
Application of fertilizer	76	10.2
Application of manure	14	1.8
Create mounds	2	0.3
Cultivate drought resistant varieties	41	5.5
Early cultivation	2	0.3
Early harvesting	1	0.1
Good spacing	3	04
Inter cropping	2	0.3
Irrigation	65	8.7
Mulching	12	1.6
Nothing	222	29.8
Planting in rows	2	0.3
Pray for God's intervention	2	0.3
Provide water for livestock	6	0.8
Pruning	1	0.1
Regular weeding	169	22.7
Replanting	7	0.9
Shifting cultivation	3	0.4
Spraying of agrochemicals	16	2.1
Treating seeds before planting	1	0.1
Total	**746**	**100**

Table 6b: Farmers' adaptive responses to low/little rainfall in the Gambia

Response	Freq.	Per.
Nothing	33	33
Pray to God	4	4
Seek advise from agriculture extension agents	7	7
Supplement feed and water for livestock	17	17
Water the livestock and provide extra	3	3
No response	36	36
Total	**100**	**100**

Table 7a: Farmers' adaptive response to excessive rainfall

Response	Freq.	Per.
Apply cow dung	2	0.3
Construct trenches	135	18.1
Early harvesting	12	.6
Feed animals	2	0.3
Frequent weeding	35	4.7
Green belt		0.1
House livestock	7	0.9
Mulching	2	0.3
Nothing	372	49.9
Pruning	3	0.4
Raise beds		0.1
Relocate		0.1
Replanting	10	1.3
Set fire to provide warmth		0.1
invoke the spirits of our ancestors	2	0.3
Creates terrace on the field		0.1
Never experienced such events	159	21.3
Total	**746**	**100**

Table 7b: Farmers' adaptation to excessive rainfall

Response	Freq.	Per.
Construct trenches	5	5
House livestock	5	5
Increase farming area	1	1
Nothing	23	23
Report to veterinary officers	32	32
No response	34	34
Total	**100**	**100**

4.4 Agricultural Innovation

4.4.1 Famers' Innovations

The results from Ghana show that not many farmers had introduced innovations on their farms as a response to climate change. Indeed about 79% of the respondents said they have not introduced any innovations whereas about 21% of the respondents said they had. Table 8 a shows that majority of the those who introduced innovations got some new improved crop varieties and or livestock breeds. Other innovations included new information about agricultural activities and introduced improved farm tools and practices (Table 8a).

Table 8a: Farmers' innovation in products and services within the past three to five years in relation to climate change in Ghana

Innovation in product or service	Yes (%)	No (%)
New or improved crop/livestock breed	334(44.8)	412(55.2)
New or improved farm tool/practice	136(18.2)	610(81.8)
New Information	139(18.6)	607(81.4)
New market products	93(12.5)	653(87.5)
Upgraded machinery or equipment on your farm within the past years	88(11.8)	658(88.2)

Table 8b: Farmers' innovation in products and services within the past three to five years in relation to climate change in the Gambia

Innovation in product or service	Yes %	No %
New or improved crop/livestock breed	87	13
New or improved farm tool/practice	24	76
New Information	24	76
New market products	2	98
Upgraded machinery or equipment on your farm within the past 3 - 5 years	4	96

Similarly, in the Gambia, 72% of the respondents said they have not introduced any innovations whereas 28% said they had introduced some innovations in their farming activities. Table 8b shows the specific types of innovations they have introduced over the past three to five years. The table shows that the most introduced innovations have been on improved crops and livestock breeds, improved farm tools or practices and new information on agricultural activities.

5. Preliminary Conclusions & Recommendations

Farmers in Ghana and the Gambia have perceived that the climate is changing and this is manifested in the form of erratic rainfall patterns and rising temperatures. Farmers have also identified other environmental challnges such as loss of vegetation cover and wildlife in their communities, although it may difficult to ascribe these to the effects of climate change.

Furthermore, farmers reckon the impacts of climate change on their farming activities, however, many of them did nothing to respond when their farms receive little rainfall, excessive rainfall, or when their crops and livestock are attacked by diseases and pests. Even for many of those farmers who did something, they have many times reported to the Agriculture Extension Agents or bought and applied fertilizer and agrochemicals.

The Study has shown that farmers do not see the impact of climate change as a threat that will prevail for a long time and thus may be the reason for them doing nothing when they are affected but hoping that the situation will change for the better.

Notwistanding, farmers have introduced some innovations in their farming activities to help improve on food production. However it is not clear if these innovations were responses to the impact of climate change since most of the farmers alluded that they ususally did nothing when they are afflicted by extreme weather events.

Therefore considering that there are innovations/technologies that have been developed by research institutions in Ghana and the Gambia, it is recommended that in the short to medium term, the agriculture extension agents be trained on some of these innovations/technologies to enable them reach farmers with these innovations. In the long term, there are some innovations/technologies that need capital investments to deploy. In this case, there is need for stronger collaborations to be established between the research intitutions, civil society and the private sector to to bring these technologies to farmers.

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African Technology Policy Studies Network
Contact the Executive Director at
The Chancery, 3rd Floor, Valley Rd.
P O Box 10081, 00100-Nairobi, Kenya
Tel: (254 020) 2714092, 2714168, 2714498, 2723800
Fax: (254 020) 2714028

http://www.atpsnet.org

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